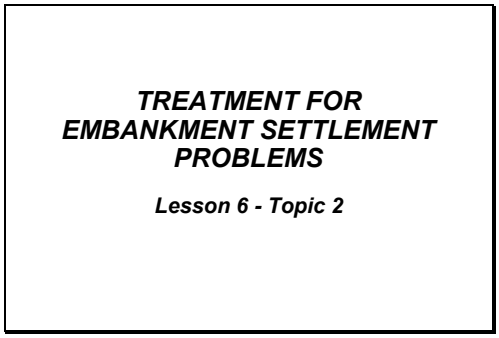
LESSON 6

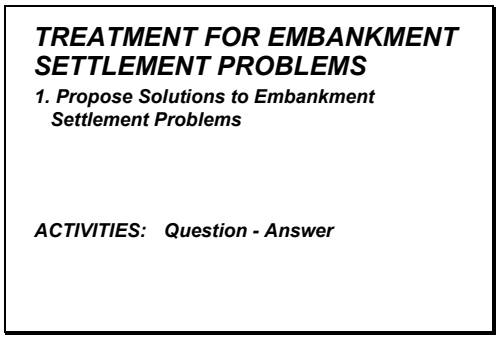
TOPIC 2

Treatment for Embankment Settlement Problems



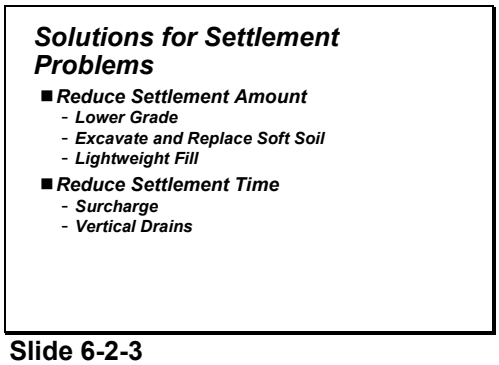
Slide 6-2-1

Header



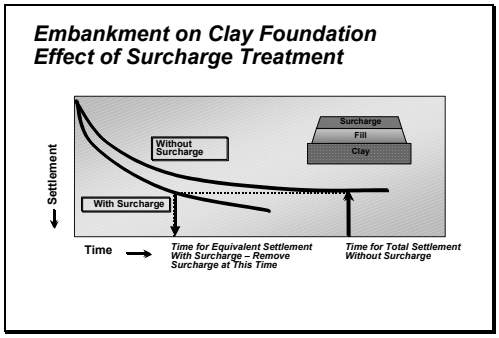
Slide 6-2-2

Objective



Slide 6-2-3

Introduce concepts of treatment for settlement.

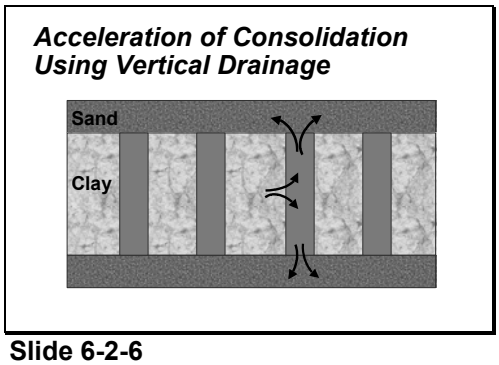


Slide 6-2-4

Explain the surcharge concept. Stress that the increased load placed on the soil does not change the drainage properties of the soil deposit. However a percentage of the total settlement will occur within a given time frame for a given soil deposit. Therefore if an increased load is applied, an amount of settlement equal to the settlement under the original load will occur in a shorter time. Note that a surcharge must be removed when the planned settlement has occurred.

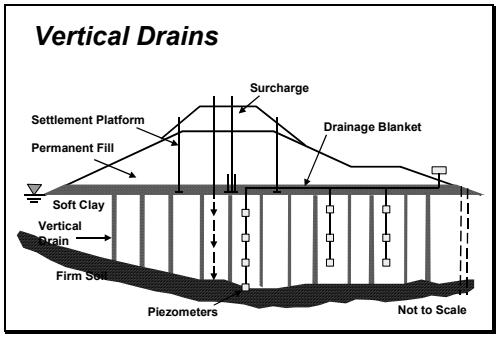
Slide 6-2-5

Surcharge case history. This is a surcharge placed on the Salt Lake City I-15 project. Note that the lateral extent of the surcharge was maximized by using a soil reinforcement system to build the surcharge with a vertical face. Also note that a relatively high embankment was being surcharged at this location. The design attempted to maximize the surcharge height as the relative proportion of surcharge load was small compared to the total embankment load.



Slide 6-2-6

Show vertical drain concept. Note that drains are most effective for wide embankments over deep clay layers. Explain the process of first constructing a permeable drainage layer over the original ground to allow the discharge to flow out to the sides of the fill. The spacing is designed based on the type of drain and the soil properties. The drains are installed by a variety of equipment depending on drain type and soil conditions. The water flow from the drains is caused by the pressure induced in the pore water by the embankment load.

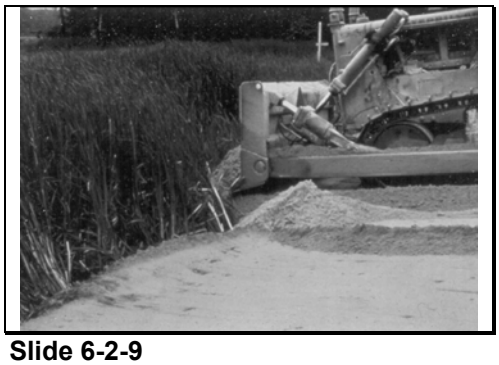


Slide 6-2-7

Show typical cross section of vertical drain installation. Mention the use of instrumentation to monitor the actual rate of consolidation of the soil deposit. Remind students that settlement is primarily caused by squeezing water out of the soil deposit.

Slide 6-2-8

Show example of soil type suitable for vertical drainage then use a sequence of slides to demonstrate how a typical drain project would proceed and options available for drain types.



Slide 6-2-9

Drainage blanket placement.

Vertical Drain Installation Sequence

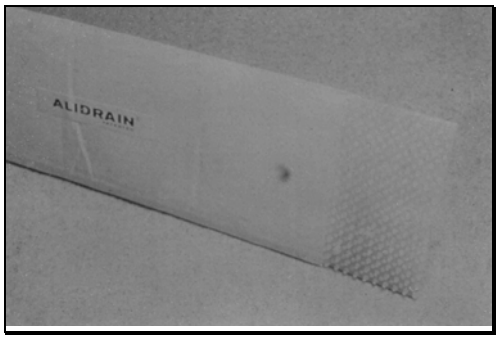
- ***Position Rig at Drain Location***
- ***Place Anchor on Drain End***
- ***Penetrate Mandrel to Desired Depth***
- ***Withdraw Mandrel***
- ***Cut Drain Material Above Drainage Blanket***

Slide 6-2-10

Overview sequence of prefabricated drain installation prior to showing a series of slides of the actual construction operations.

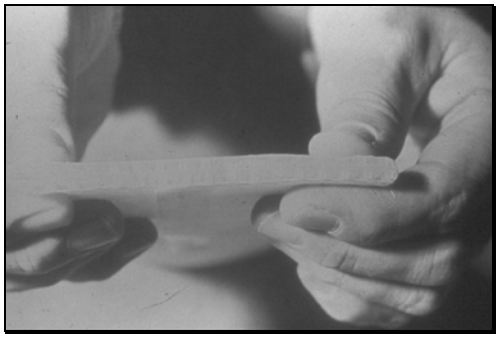
Slide 6-2-11

Prefabricated drain material have virtually replaced sand drains in recent years. The material is relatively inexpensive and the installation process rapid. The drain material is manufactured in rolls as shown here.



Slide 6-2-12

Typical prefabricated drain which has a plastic corrugated core to allow water flow up the drain and a filter fabric jacket to prevent fines from entering the drain. Typical drain width is about 4”.



Prefabricated drain thickness generally vary from 0.1” to ¼”.

Slide 6-2-13

Drain installation equipment.

Slide 6-2-14

The mandrel and the end anchor are shown for the prefabricated drain. Note that manufacturers have tried to limit the cross sectional area of the mandrel and drain to reduce displacement and resulting soil disturbance which reduces flow to the drain.

Slide 6-2-15

Mandrel fully inserted.

Slide 6-2-16

Mandrel withdrawn with drain ready for trim.

Slide 6-2-17

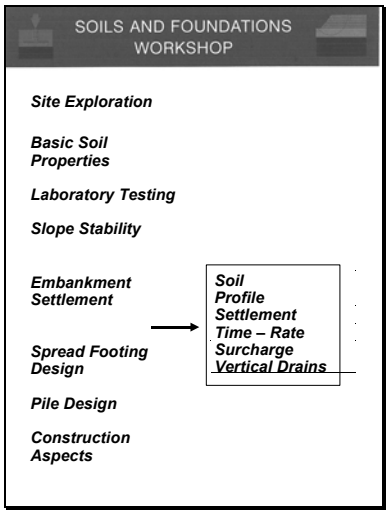
Final in place prefabricated drain. Note that prefabricated drain can be placed at average rates of 40' per minute depending on conditions. Length of drain may be limited by the equipment as the mandrels tend to be relatively thin and flexible. Also compact surface deposits may need to be pre-augered to allow mandrel penetration.

Slide 6-2-18

Slide 6-2-19

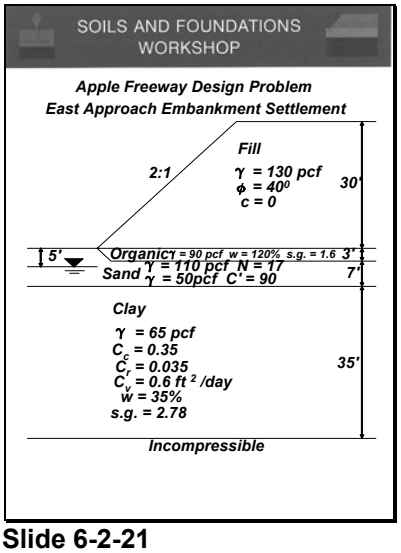
Final installation, note close drain spacing.

After slides, pass around a sample of a wick drain.



Slide 6-2-20

Summary of progress on Apple Freeway design problem.

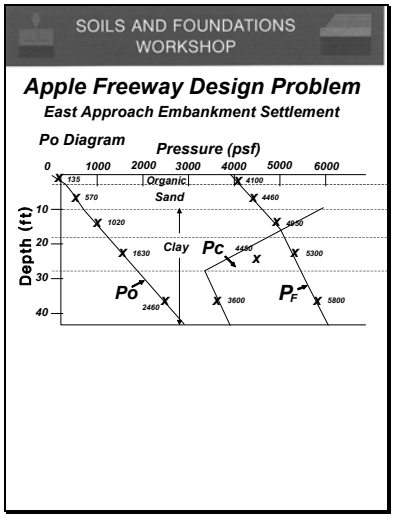


Slide 6-2-21

Show Apple Freeway soil profile for the East approach.

Ask students which layer will settle the most.

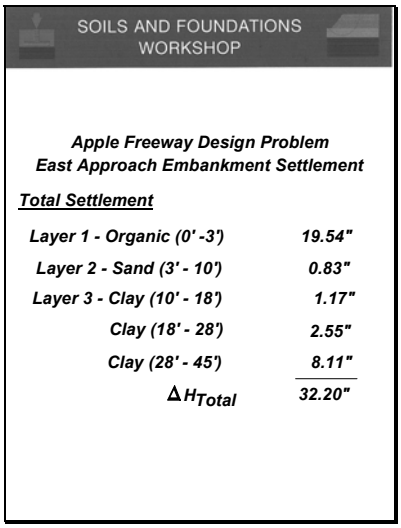
Ask the students to explain the process for calculating the settlement.



Slide 6-2-22

Ask how preconsolidation impacts settlement amount.

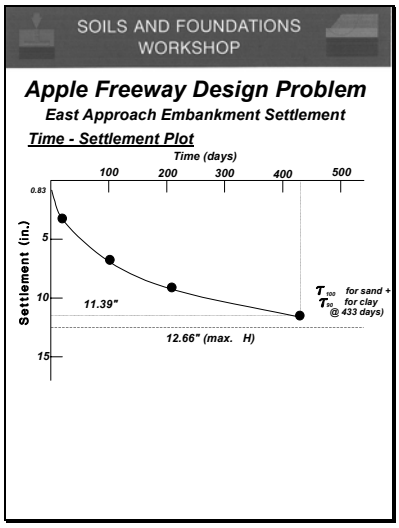
Answer: Reduces amount



Slide 6-2-23

Ask the best method to use to cheaply reduce the settlement.

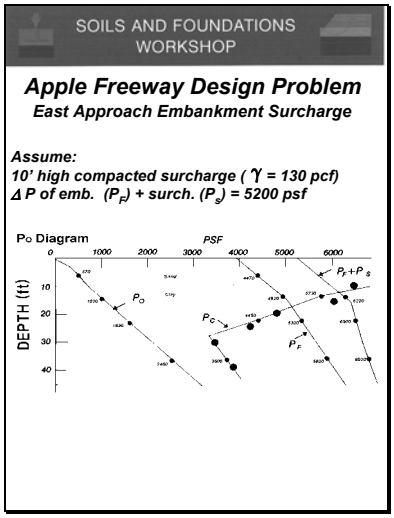
Answer: Excavate organic soil.



Slide 6-2-24

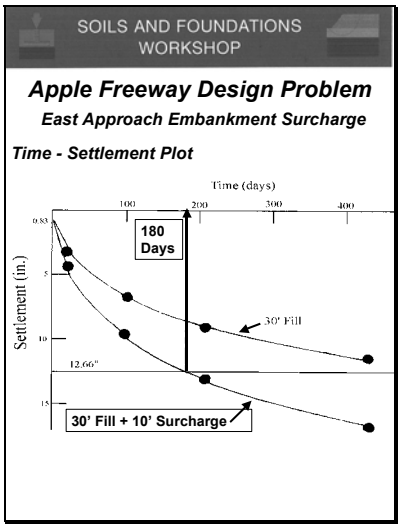
Show results of time settlement and ask how settlement amount or time can be further reduced.

Answer: Excavate soft soil, lightweight fill, surcharge, or vertical drains. Note lowering grade not an option due to clearance requirements over Apple freeway.



Slide 6-2-25

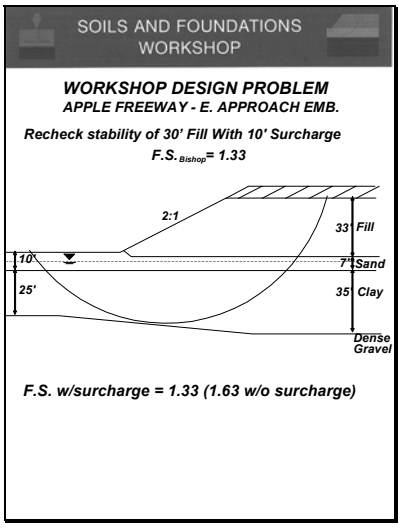
Show surcharge design.



Slide 6-2-26

After showing this two-overhead sequence, the instructor asks what else needs to be checked in design prior to approving the use of a surcharge.

Answer: Stability of embankment plus surcharge.



Slide 6-2-27

Ask if safety factor is ok.

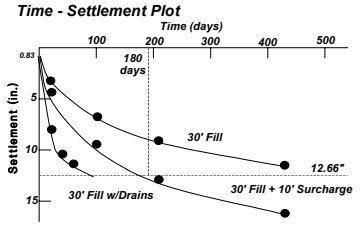
Answer: Yes.

SOILS AND FOUNDATIONS WORKSHOP

Apple Freeway Design Problem

East Approach Embankment Settlement

Time - Settlement Plot



Treatment	t_{90} (mo.)	Extra Cost
Fill only	14	-
Fill w/10' surcharge	6	$120,000
fill w/ wick drain	2	$172,000
Fill w/sand drain	2	$385,000

Slide 6-2-28

Show Apple Freeway summary for decision making by management. Then ask if we need to check anything else.

Answer: Lateral squeeze

SOILS AND FOUNDATIONS WORKSHOP

Apple Freeway Problem
East Approach Embankment Settlement

Lateral Squeeze of Clay

Remember: $\gamma_{Fill} \times H_{Fill} > 3 \times$ Cohesion

3900 psf > 3300 psf

-> Can get lateral squeeze of clay

"Rule of Thumb"

Horizontal abutment movement:

= 0.25 x Fill Settlement

= (0.25)(11.8) = 3"

-> Recommend waiting period at abutment to remove settlement and prevent horizontal movement of abutments.

Slide 6-2-29

Show lateral squeeze issue.

SOILS AND FOUNDATIONS WORKSHOP

Approach Embankment Settlement

Design Soil Profile

Soil layer consolidation properties selected

Settlement

32" settlement predicted
Recommend organic excavation
Rec. waiting period @ abut.

Time-Rate

433 days for t_{90}

Surcharge

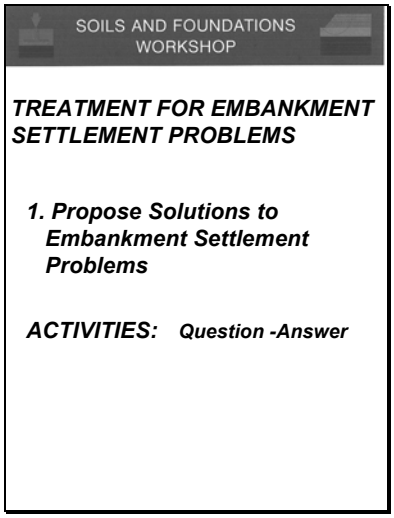
10' surcharge improves t_{90} to 190 days
Cost $120,000, F.S. = 1.33 O.K.

Vertical Drains

60 days for t_{90}
Cost $172,000 -> $385,000

Slide 6-2-30

Summarize status of Apple Freeway design



Slide 6-2-31

Review objectives from beginning of class.

Note that the first two project phases have been completed; data gathering and embankment design. Now structural design can begin.